1	HIGH-SPEED OPTICAL DATA LINKS
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3	CROSS-REFERENCE TO RELATED APPLICATION
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5	This application claims the benefit of U.S. Provisional
6	Application serial no. 60/306,697, filed 20 July 2001.
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8	Field of the Invention
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10	This invention relates to optical transmitters,
11	receivers, and transceivers.
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13	More specifically, this invention relates to data links
14	in optical transmitters, receivers, and transceivers.
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17	Background of the Invention
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19	Optical transmitters, receivers and transceivers are
20	used for converting electrical data into optical data for
21	transmission on optical fibers and for converting optical
22	data back into electrical data for processing by network
23	equipment. Normally, an optical transmitter includes a
2./	light source such as a laser driver and a laser diode and

an optical receiver includes a light conversion device, 1 such as a post amplifier, a trans-impedance amplifier and a 2 PIN photodiode or an APD. The transmitter or receiver is 3 generally mounted on a network circuit board to interface 4 with other data processing IC chips, such as a serializer 5 or de-serializer, a data framer for coding, such as 8B/10B 6 coding, and a higher level data control IC. This type of 7 structure, however, fails to perform when the 8 transport rate reaches around 10 Gbps or beyond, as the 9 electric traces on the printed circuit board introduce 10 noises and jitters and distort the signal integrity at such 11 a high frequency. 12

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Current technology requires that a serializer and de-14 serializer be integrated into the transmitter and receiver 15 module or modules to allow electrical interfaces to operate 16 at lower frequency. As an example, for an OC192 data rate, 17 the electrical interfaces for the data link module will 18 require 16 channels of 622 Mbps. The module, which is 19 called a fiber optical transponder, can then be mounted 20 onto the board to interface with other IC chips to fulfill 21 the network management function. Consequently, the module 22 requires many electrical interfaces, typically with more 23 than 50 pins. The large number of pins and the extra 24

- 1 internal circuitry dictates that the module size is large.
- 2 The power consumption is also a serious issue.

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- 4 It would be highly advantageous, therefore, to remedy
- 5 the foregoing and other deficiencies inherent in the prior
- 6 art.

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- 8 Accordingly, it is an object the present invention to
- 9 provide a new and improved high-speed optical data link.

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- 11 Another object of the present invention is to provide a
- 12 new and improved high-speed optical data link capable of
- 13 conveying data at around 10 Gbps rates or beyond.

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- And another object of the present invention is to
- 16 provide a new and improved high-speed optical data link
- 17 that is simple and relatively inexpensive to manufacture.

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- 19 Still another object of the present invention is to
- 20 provide a new and improved high-speed optical data link
- 21 that is smaller than prior art devices and less electrical
- 22 pin counts capable of conveying information at similar
- 23 rates.

Summary of the Invention

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3 Briefly, to achieve the desired objects of the present invention in accordance with a preferred embodiment 4 thereof, provided is a high-speed optical data 5 including a system board with first and second ASICs 6 mounted thereon. The first ASIC includes a clocking and an 7 equalization function for recovering distorted data. The 8 second ASIC is electrically coupled to the first ASIC for 9 conveying electrical signals therebetween and the second 10 includes one of a clocking and an equalization 11 ASIC function for recovering distorted data. 12

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In a more specific embodiment, a high-speed optical 14 first ASIC coupled to link includes a 15 electrical information to a remote circuit and a second 16 ASIC electrically coupled to the first ASIC for conveying 17 electrical signals therebetween. A fiber optic receiver 18 module is mounted on the system circuit board and includes 19 a photo diode positioned to receive optical signals from a 20 remote source, a trans-impedance amplifier electrically 21 coupled to the photo diode, and a post-amplifier, such as a 22 limiting amplifier or an auto-gain control circuitry, 23 24 electrically coupled to the trans-impedance amplifier and

1 to the second ASIC. The second ASIC includes a clocking

2 and an equalization function for data integrity and the

3 first ASIC includes a function for recovering distorted

4 data through the same clocking and an equalization scheme

5 as provided by the second ASIC.

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more specific embodiment a high-speed 7 another In optical data link also includes a first ASIC coupled to 8 receive electrical information form a remote circuit and a 9 second ASIC electrically coupled to the first ASIC for 10 conveying electrical signals therebetween. A fiber optic 11 transmitter module mounted on the system circuit board 12 includes a laser positioned to convey optical signals to a 13 remote source and a laser driver electrically coupled to 14 the laser and to the second ASIC. The first ASIC includes 15 a clocking and may include an equalization function for 16 transmission and the second ASIC includes 17 data equalization function for recovering distorted data through 18 the same clocking. It should be noted that both of the 19 last two embodiments described can, optionally, be packaged 20 and included on a common board with the first and second 21

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ASICs being common.

The embodiments described above include a novel method

of electrically communicating information at 10-gigabits 1 per second or beyond on a circuit board. The method 2 includes the steps of providing a system circuit board 3 including a first position and a second position, receiving 4 electrical signals from an external source at the first 5 position on the system circuit board, clocking and 6 equalizing the electrical signals on the system circuit 7 board for providing signals with integrity, conveying the 8 equalized signals to the second position on the system 9 circuit board, and receiving the equalized signals at the 10 second position and recovering distorted signals using a 11 de-clocking and re-timing step. 12

1	Brief Description of the Drawings
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3	The foregoing and further and more specific objects and
4	advantages of the invention will become readily apparent to
5	those skilled in the art from the following detailed
6	description of a preferred embodiment thereof, taken in
7	conjunction with the drawings in which:
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9	FIG. 1 is a simplified block diagram/top plan of a
10	prior art optical data link; and
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12	FIG. 2 is a simplified high speed optical data link in
13	accordance with the present invention.

Detailed Description of the Drawings

3	Referring to FIG. 1, a simplified block diagram/top
4	plan of a prior art optical data link 100 is illustrated.
5	Data link 100 includes a system board 101 with a fiber
6	optic transponder 110 mounted thereon. Electrical
7	connections for the various components of transponder 110
8	are not illustrated since they are provided, in a well-
9	known manner, through internal connections in the mounting
10	structure. Transponder 110 includes a
11	serializer/deserializer 112 electrically connected to a
12	transimpedance amplifier and post-amplifier 114, which is
13	in turn electrically connected to PIN photodiode 116.
14	Photodiode 116 is positioned to receive modulated light
15	signals from an optical fiber, represented by an arrow 140.
16	Serializer/deserializer 112 is also electrically connected
17	to a laser driver 118, which is in turn connected to drive
18	a laser diode 120. Laser diode 120 is positioned to supply
19	modulated output light to an optical fiber, represented by
20	an arrow 130. Input and output electrical signals for
21	transponder 110 are supplied by an electric interface,
22	including connectors and printed circuit board copper
23	traces designated 160, from board level IC chips, generally
24	designated 150.

The connectors and traces of electrical interface 160 1 on printed circuit board 101 introduce noises and jitters 2 that distort the signal integrity, at high frequencies 3 (e.g., in the 10-gigabits per second range or above), of 4 signals communicated between transponder 110 and board 5 level IC chips 150. Because of this distortion, electrical 6 interface 160 must operate at lower frequencies, which 7 requires a large number of channels. For example, a 10 8 signal is converted by serializer/deserializer 112 9 channels of differential signals 622 Mbps. 16 10 into use of serializer/deserializer 112 11 However, the transponder 110 and the 16 channels, greatly increases the 12 number of pins or connections in electrical interface 160. 13 associated connections channels and 16 14 The increases the size and power requirements of transponder 15 110. 16

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Turning now to FIG. 2, a simplified high-speed optical 18 data link 200 in accordance with the present invention is 19 illustrated. Data link 200 includes a system board 201 20 with a fiber optic transceiver 210 mounted thereon. 21 Electrical connections for the various components of 22 illustrated since they transceiver 210 are not 23 provided, in a well-known manner, through internal 24

connections in the mounting structure. Transceiver 210 1 includes a first ASIC 212 electrically connected to a light 2 illustrated herein for exemplary 3 converting device, transimpedance/post amplifier 214 4 purposes as a electrically connected to a PIN photodiode 216. Photodiode 5 216 is positioned to receive modulated light signals from 6 an optical fiber, represented by an arrow 240. ASIC 212 is 7 also electrically connected to a light generating device, 8 herein illustrated for exemplary purposes only as a laser 9 driver 218 connected to drive a laser diode 220. 10 diode 220 is positioned to supply modulated output light to 11 an optical fiber, represented by an arrow 230. 12

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Input and output electrical signals for transceiver 210 14 are supplied by an electric interface, including connectors 15 and printed circuit board copper traces and the 16 designated 260. Board level IC chips, generally designated 17 250, include a second ASIC 252, which is connected by 18 electrical interface 260 to first ASIC 212 in transceiver 19 While a transceiver incorporating both an optical 20 transmitter and an optical receiver is illustrated in this 21 example for purposes of explanation, it will be understood 22 that the pair of ASICs can be used with single optical 23

1 transmitters, single optical receivers, optical

2 transceivers, or any combination of these devices.

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By incorporating the pair of ASICs in the optical 4 transmitter, receiver, or transceiver, a 10 Gbps or higher 5 serial electrical interface can be established directly 6 between transceiver 210 and system board 250 through normal 7 electrical interfaces 260, such as pin-grid-array, ball-8 grid-array, edge connectors, etc. A clock data recovery 9 (CDR) is built into each of the ASICs 212 and 252. Also, 10 each of the ASICs 212 and 252 operate to receive electrical 11 signals from interface 260 and to transmit electrical 12 signals through interface 260. Either ASIC 212 or ASIC 252 13 retimes and clocks the signal and provides driving power 14 for the transmitting portion. For the receiving portion of 15 ASICs 212 and 252, they both handle and recover the 16 17 distorted data due to high frequency signal transmitting directly on the electric traces of the circuit board. 18

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The clock and equalization/retiming can be performed using a variety of techniques, one of which is described in detail in a paper by Abhijit Phanse presented to the IEEE in New Orleans in September 2000, a copy of which is appended hereto and incorporated by reference.

Thus, each fiber optic data link includes a fiber optic 1 2 transmitter module with a first ASIC to equalize/retime and recover electric data distorted by the electric traces on 3 the system board and a second ASIC mounted in the system 4 printed circuit board to clock and equalize the electric 5 data and provide driving power for transmitting to the 6 optical transmitter module through electric traces on the 7 printed circuit board. The described fiber optic data link 8 system operates at a data rate of more than 5 Gbps. 9 preferred embodiment, the second ASIC on the system board 10 includes a clocking and equalization function for data 11 transmission over printed circuit traces and the first ASIC 12 module includes а function transmitter 13 the recovering the distorted data through the same coding and 14 clocking scheme provided by the second ASIC. In another 15 embodiment, the second ASIC on the system board includes a 16 serializer for data serialization, a clocking, 17 equalization function, and the driving power for data 18 transmission over printed circuit traces, and the first 19 ASIC in the transmitter module includes a function for 20 recovering the distorted data through the same clocking 21 scheme provided by the second ASIC. 22

As a typical example, the fiber optic data link 1 2 includes a fiber optic receiver module mounted on a system printed circuit board. The fiber optic receiver module 3 includes a photo diode, a trans-impedance amplifier, a post-amplifier, and a first ASIC to clock and equalize 5 electric data and provide electric driving power for 6 transmitting to the system printed circuit board through 7 electrical traces on the printed circuit board. The system 8 printed circuit board includes a second ASIC connected and 9 designed to recover electric data distorted by the electric 10 traces on the system printed circuit board. 11 embodiment, the first ASIC on the receiver module includes 12 a clocking and retiming function for data transmission and 13 provides electric signal driving power, and the second ASIC 14 on the system board includes a function for recovering the 15 distorted data through the same clocking scheme provided by 16 the first ASIC. Also in this example, the first ASIC on 17 the receiver module includes a clocking and equalization 18 function for data transmission, and the second ASIC on the 19 system board includes a function for recovering 20 distorted data through the same clocking scheme provided by 21 the said first ASIC and may further include a de-serializer 22 for data de-serialization. 23

In yet another example, a fiber optic data link system includes a fiber optic transceiver module mounted on a system printed circuit board, the fiber optic transceiver module includes a transmitter, including a laser diode and a laser driver, a receiver and a first ASIC.

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The receiver includes a photo diode, a trans-impedance amplifier and a post-amplifier. The first ASIC performs clocking and equalization/retiming functions to the data coming from the receiver and provides driving power for transmitting to the system board through electric traces on the printed circuit board. The first ASIC also performs the function of recovering distorted electric data coming from the system board through the electric traces on the printed circuit board for transmitting to the transmitter. The system printed circuit board includes a second ASIC for coming from the recovering electric data transceiver and distorted by the electric traces on the system printed circuit board and clocking and equalizing and providing driving power electric data transmission on the printed circuit board to the optical transceiver module.

The first ASIC on the transceiver module also includes 1 a clocking and equalization/retiming function for data 2 receiver side, а function 3 transmission on the recovering the distorted data through the same clocking 4 scheme as provided by the second ASIC on the system board, 5 and the second ASIC on the system board includes a function 6 for recovering the distorted data through the same clocking 7 scheme provided by the first ASIC and clocking functions 8 for transmitting data to the transceiver through the 9 electric traces on the circuit board. The first ASIC on 10 the transceiver module also includes a clocking function 11 and coding function for data equalization on the receiver 12 side, a function for recovering the distorted data through 13 the same coding scheme as provided by the second ASIC on 14 15 the system board.

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The second ASIC on the system board includes a function for recovering the distorted data through the same retiming and clocking scheme provided by the first ASIC, a clocking and equalization function for transmitting data to the transceiver through the electric traces on the circuit board, a serializer function for data serialization and describing the serializer for data describing.

Thus, a new and improved high speed optical data link 1 is disclosed which includes a pair of ASICs that provide 2 clocking and equalization functions for transmitting data 3 through system boards at rates in the 10-Gbps range or 4 By doing so, the fiber optic module, such as 5 transmitter, receiver or transceiver, will have smaller 6 size, lower power consumption, and less electrical pin 7 counts. It is also easier to make the transceiver 8 9 pluggable.

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Various changes and modifications to the embodiments
herein chosen for purposes of illustration will readily
occur to those skilled in the art. To the extent that such
modifications and variations do not depart from the spirit
of the invention, they are intended to be included within
the scope thereof, which is assessed only by a fair
interpretation of the following claims.

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Having fully described the invention in such clear and concise terms as to enable those skilled in the art to understand and practice the same, the invention claimed is: